

Appendix II

Floodway Encroachment Calculations

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Appendix II

Floodway Encroachment Calculations

1 Introduction

The evaluation of the impact of floodplain encroachments on water surface profiles can be of substantial interest to planners, land developers, and engineers. It is also a significant aspect of flood insurance studies. HEC-2 contains six optional methods for specifying floodplain encroachments. Each method is illustrated in the following paragraphs. Also program options related to encroachment determinations, data organization, and encroachment output will be covered.

2 Encroachment Method 1

With Method 1 the user specifies the exact location of the encroachment for a given cross section. Stations and elevations which apply to all profiles of the left and/or right encroachment, are specified on the X3 record for individual cross sections as desired. Encroachment stations for individual cross sections can also be specified differently for each profile by using the ET record. A 9.1 in the INQ field (J1.2) of the ET record would indicate that Method 1 is being used (for current cross section only), and the left and right encroachment stations are specified on Fields 9 and 10 of the ET record.

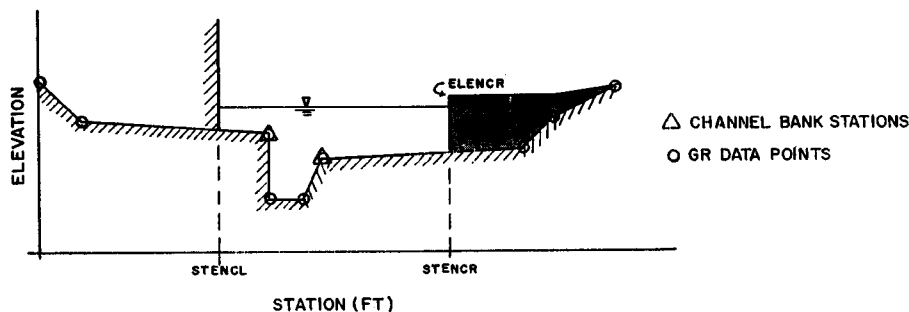


Figure 1
Encroachment Method 1

3 Encroachment Method 2

Method 2 utilizes a fixed top width. The top width (ENCFP) can be specified on an ET or X3 record which will be used for the current and **all subsequent cross sections** until changed by another X3 or ET record. The left and right encroachment stations are made equal distance from the centerline of the

channel, which is halfway between the left and right bank stations. A 200.2 in the INQ (J1.2) of the ET record would indicate a 200 foot width will be used for Method 2. No provision is made to insure that all of the channel area is retained as flow area.

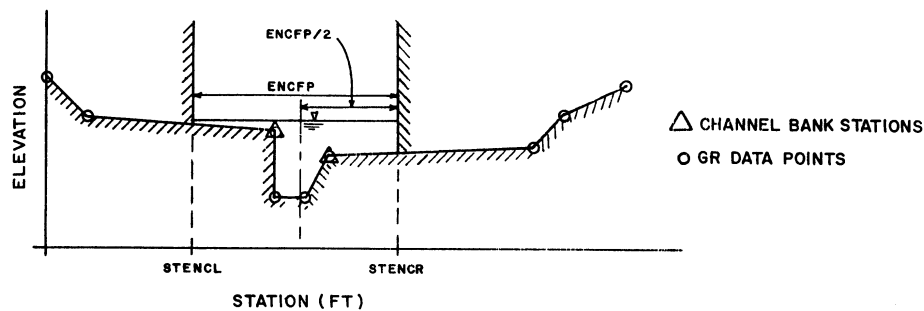


Figure 2
Encroachment Method 2

4 Encroachment Method 3

Method 3 calculates encroachment stations for a specified percent reduction (PERENC) in the natural conveyance of each cross section. One-half of PERENC is eliminated on each side of the cross section (if possible) as long as the encroachments do not infringe on the main channel. If one-half PERENC exceeds either overbank conveyance, the program will attempt to make up the difference on the other side. If the percent reduction in cross section conveyance cannot be accommodated by both overbank areas combined, the encroachment stations are made equal to the

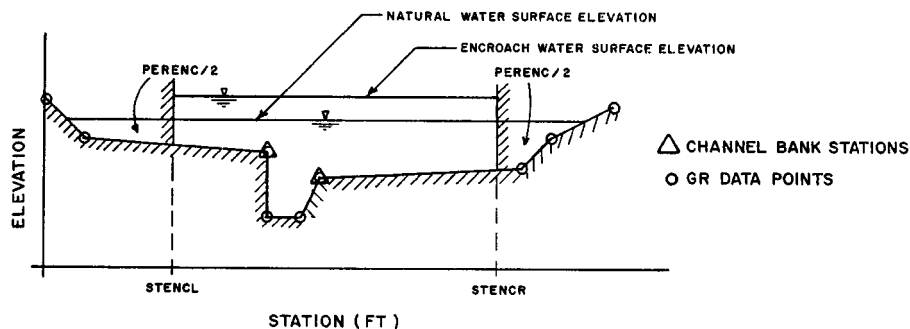


Figure 3
Encroachment Method 3

stations of left and right channel banks. This method requires that the first profile (of a multiple profile run) must be a natural (unencroached) profile. Subsequent profiles of multiple profile runs may be utilized for Method 3 encroachments. The amount of conveyance reduction is requested by percentages specified on the ET record. The percentage can be changed by inserting another ET record ahead of the appropriate cross section. A 10.3 in the INQ field (J1.2) of the ET record for the second profile would indicate that 10 percent of the conveyance based on the natural profile (first profile) will be eliminated - 5 percent from each overbank. An alternate scheme to **equal** conveyance reduction is conveyance

reduction in **proportion** to the distribution of natural overbank conveyance. For instance, if the natural cross section had twice as much conveyance in the left overbank as in the right overbank, a 10.3 value would reduce 5 percent conveyance in each overbank, whereas a -10.3 value would reduce 6.7 percent from the left overbank and 3.3 percent from the right overbank.

5 Encroachment Method 4

Method 4 computes encroachment stations so that conveyance within the encroached cross section (at some higher elevation) is equal to the conveyance of the natural cross section at the natural water level. This higher elevation is specified as a fixed amount above the natural (e.g., 100 year) profile. The encroachment stations are determined so that an equal loss of conveyance (at the higher elevation) occurs on each overbank, if possible. If half of the loss cannot be obtained in one overbank, the difference will be made up, if possible, in the other overbank, except that encroachments will not be allowed to fall within the main channel.

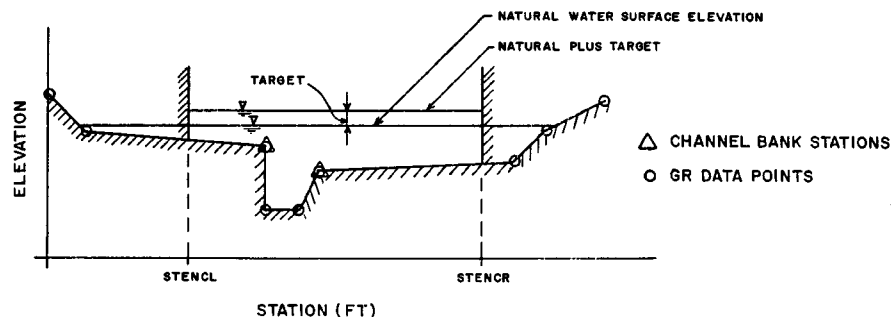


Figure 4
Encroachment Method 4

A 10.4 in the INQ field (J1.2) of the ET record indicates that a 1 foot rise (value is in tenths of a foot on the left side of the decimal point) will be used to determine the encroachments based on equal conveyance. An alternate scheme to **equal** conveyance reduction is to reduce conveyance in **proportion** to the distribution of natural overbank conveyance (a value of -10.4). See Method 3 for an explanation of this. Also, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

6 Encroachment Method 5

Method 5 operates much like Method 4 except that an optimization scheme is used to obtain the target difference in water surface elevation between natural and encroached conditions. A maximum of 21 trials is allowed in attempting a solution. The routine uses the percent reduction in conveyance as the objective function to be optimized to obtain the desired target. Convergence is usually obtained in three of four trials. The number of trials processed is printed under the variable name ICONT. Equal conveyance reduction is attempted in each overbank. Input for Method 5 is specified on the ET record in the same fashion as for Method 4. A 10.5 value in the INQ field (J1.2) of the ET

record would indicate a target of 1 foot difference in water surface elevations. This method can be changed before any cross section, like Methods 1 through 4. Also, as with Methods 3 and 4, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

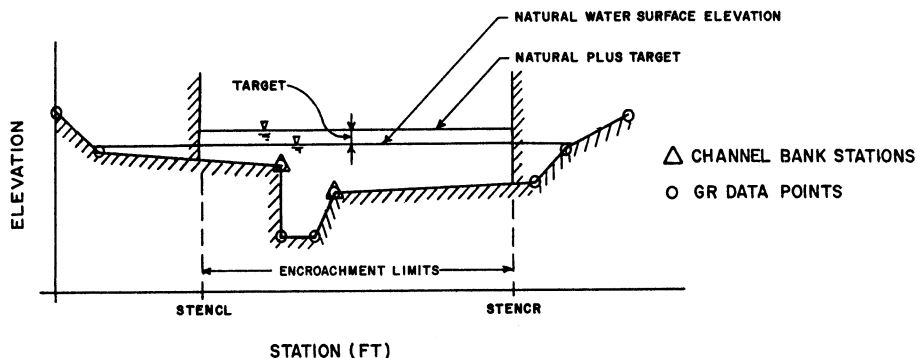


Figure 5
Encroachment Method 5

7 Encroachment Method 6

Method 6 operates in the same manner as Method 5 except that the optimization is based on obtaining a target difference in energy grade line elevation between natural and encroached conditions. Input for Method 6 is specified on the ET record and can be changed before any cross section, like Methods 1 through 5. A 10.6 in the INQ field (J1.2) of the ET record would indicate a floodway with a target of 1 foot difference in energy elevations. Also, the first profile must be for natural (unencroached) conditions and subsequent profiles can be computed for different targets.

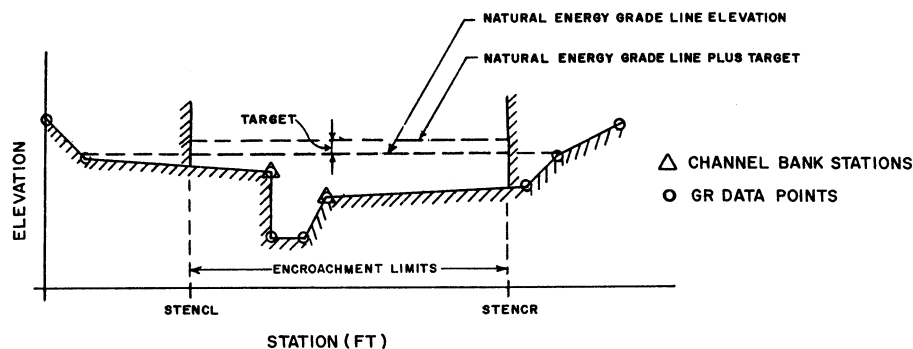


Figure 6
Encroachment Method 6

8 Bridge Encroachments

Each of the six methods can be used to evaluate the effect of encroachments on bridges (BT records). Bridge encroachments for special bridge analysis must be requested by adding a .01 to the

code on the ET record for the encroachment Methods 1 through 6. Thus, 9.11, 100.21, 10.31, 10.41, 10.51, or 10.61 would request the bridge encroachments for Method 1 through 6, while 9.1, 100.2, 10.3, 10.4, 10.5, or 10.6 would not encroach BT records. The following table describes how each method handles encroachments on special bridges.

Table 1
Encroachments on Special Bridges

Method	Special Bridge Encroachments
1	Bridge encroachments defined by target values of Method 1.
2	Bridge encroachments defined by target values of Method 2.
3 - 6	Bridge encroachments defined by encroachments determined at the cross section immediately downstream of the bridge.

Without this option, the program will not calculate encroachments on special bridge or special culvert models. For normal bridge models BT data encroachments are handled in the same manner as GR data encroachments.

9 Flow Distribution Option

This option is recommended when computing floodway encroachments. With flow distribution the program prints out the lateral distribution of area, velocity, and discharge in the overbank subareas (formed by points on the GR record) for each cross section. Because the distribution of discharge is given as a percent, it can also be considered a percentage-distribution of conveyance.

The flow distribution option is called by setting the variable ITRACE (J2.10 or X2.10) equal to 15. If the number of subareas carrying flow in the overbanks is less than 11, the distribution using all subareas will be printed. Otherwise, the distribution will be based on sub-areas that carry more than 3 percent of the flow. An example of flow distribution is shown in Figure 11, on page 40.

10 Encroachment Data Organization

The table on the following page illustrates a possible organization of data records for an encroachment analysis. Only the variables directly associated with encroachment analysis are shown in the table. For this example, three profiles are calculated with the first profile as the natural profile. Both profiles two and three are initiated with encroachment Method 4; other methods are then used for subsequent cross sections.

11 Computer Output for Floodway Calculations

11.1 Notes in Normal Output

3470 Encroachment Stations = W, X Type = Y, Target = Z. The values of STENCL and STENCR (left and right encroachment stations) are W and X. The method used in determining these stations is method Y and the specified target (width or percent) for that method is Z. If the target is percent, a ratio less than one is used instead of percent so that a percent target can be distinguished from a topwidth target.

2800 Natural Q1 = A, WSEL = B, ENC Q1 = C, WSEL = D, Ratio = E. This note is printed out for encroachment Methods 3 through 6. The index discharge (Q assuming $S^{1/2} = .01$) is equal to A for the natural profile at the water elevation of B. The index discharge for the encroached cross section is equal to C at elevation D. Elevation D is equal to B for Method 3, but is higher for Methods 4 through 6. The reduction ratio of $1-(C/A)$ is shown as E. This ratio for Method 3 is normally equal to the target for Note 3470 which is based on the input percentage on the ET record. E will be less than the target when the overbanks do not carry the target percentage of flow. The ratio is normally equal to zero for Methods 4 through 6 (the target on Note 3470 will be the equivalent ratio for Method 3), since there is no reduction in the flow carrying capability except for the raise in water elevation from B to D. When the reduction ratio, E, is negative, there is an increase in the index Q using only the channel area.

11.2 Floodway Summary Table

There are three pre-defined summary tables for floodway calculations. The tables are described in the following section. All three tables are shown in Example No. 4 output in Appendix I.

Summary Table 110 (Encroachment Data Table). Summary Table 110, requested on the J3 record, provides information relating to encroachment analysis. The column headings for Table 110 are described below.

- a. SECNO - cross section number
- b. CWSEL - computed water surface elevation
- c. DIFKWS - the difference between the computed water surface elevations for each profile and the first profile (which should be the natural profile for encroachment options)
- d. EG - energy grade line elevation
- e. TOPWID - cross section width at the calculated water surface elevation
- f. QLOB - amount of flow in the left overbank
- g. QCH - amount of flow in the channel
- h. QROB - amount of flow in the right overbank
- i. PERENC - the target of encroachment requested on ET record



Table 2
Encroachment Data Organization

Card	Values	Comments
T1 - T3		Title information (natural profile)
J1	INQ(J1.2 = 2) WSEL(J1.9)	Read second field of ET and QT record. Starting water surface elevation is specified here.
J2	ITRACE(J2.10 = 15)	Request flow distribution for natural profile.
J3	IVAR(J3.1 = 110), IVAR(J3.2 = 200)	Summary Table 110 and 200 will be requested for summary printout.
NC QT		
ET	ENCFP(ET.2 = 0) ENCFP(ET.3 = 8.4) ENCFP(ET.4 = 10.4)	First profile is natural profile. Second profile is Method 4 with .8 foot rise. Third profile is Method 4 with one foot rise.
X1 GR X1 GR		
ET	ENCFP(ET.2 = 0) ENCFP(ET.3 = 7.4) ENCFP(ET.4 = 5.41)	First profile is natural profile (no change). Second profiles is changes to 7.4. Third profile is changed to 5.41. Bridge encroachment stations (for the BT records) will be the same as the downstream encroachments.
X1 GR		
SB		
ET	ENCFP(ET.2 = 0) ENCFP(ET.3 = 7.11) (ET.7 = STENCL) (ET.8 = STENCR) ENCFP(ET.4 = 0)	First profile is natural profile (no change). Second profile is changed to Method 1 for bridge. Bridge encroachments (for both BT and GR records are specified in the seventh and eighth fields of the ET record. Continue previous encroachment instructions.
X1 X2 BT		
ET	ENCFP(ET.2 = 0) ENCFP(ET.3 = 15.3) ENCFP(ET.4 = 10.5)	First profile is natural profile (no change). Second profile is changed to Method 3. Third profile is changed to Method 5.
X1 GR X1 GR		
EJ		End of data.
T1 - T3		Title information (Method 4 encroachment).
J1	INQ(J1.2 = 3) STRT(J1.5 = 0) WSEL(J1.9)	Read third fields of ET and QT records. Slope area method of starting should not be used for encroachment profile. Starting water surface elevation specified here.
J2	NPROF(J2.1 = 2)	Second profile.
T1 - T3		Title information (Method 4 encroachment).
J1	INQ(J1.2 = 4) STRT(J1.5 = 0) WSEL(J1.9)	Read fourth field of ET and QT records. Slope area method should not be used. Starting water surface elevation specified area.
J2	NPROF(J2.1 = 3)	Last profile.
ER		End of run.



- j. STENCL - the station of the left encroachment
- k. STCHL - the station of left bank
- l. STCHR - the station of right bank
- m. STENCR - the station of the right encroachment

Summary Table 115. A floodway distance table that provides the stations for left and right encroachment, and the center line (halfway between bank stations), plus the distance from the center station to left and right encroachment stations. These data facilitate transfer of encroachment station locations to plan maps.

Summary Table 200 (FIA Table 1). A floodway table similar to FIA Table 1 which summarizes information on floodway widths, mean velocities and water surface elevations as required for flood insurance studies. The water surface elevations and the difference rounded to a tenth of a foot for output display.